THE STUDY OF CHEMISTRY

IN

THE HIGH SCHOOLS OF ILLINOIS.

A THESIS

PRESENTED TO THE FACULTY OF THE

UNIVERSITY OF ILLINOIS

BY

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FOR THE ATTAINMENT OF THE DEGREE of

BACHELOR OF SCIENCE IN CHEMISTRY.

Clark

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A B B R E V I A T I O N S.

Report of R. Com. on Sci. Instruction --- Report of Royal Commission on Scientific Instruction.

B. of E. Cir. of Inf. --- Bureau of Education, Circular of Information.

Boone's His. of Ed. in U. S. --- Boone's History of Education in the United States.

Periodicals.

Am. J. Ed.---- American Journal of Education.

Pop. Sci. Mo.--- Popular Science Monthly.

Ed.--- Education.

STUDY OF CHEMISTRY
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The educational prominence of the science of chemistry is altogether a modern growth. (1) A century ago it was not deemed worthy of a place in the courses of any of the schools, except perhaps a very humble one in connection with the study of materia medica, physics, mineralogy or anatomy; but, to-day, chemistry ranks equally with Greek to which students for centuries have devoted their time.

In Europe at the beginning of this century France was far ahead of other countries in the advance it had made in chemistry. (2) Lavoisier, within the half century preceding, wrought a great revolution in overthrowing the phlogiston theory and had placed the science on a firmer basis. The work done in the private laboratories of Berthollet and his brilliant pupil, Gay Lussac, was attracting great attention.(3)

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(1) B. of E., Cir. of Inf., No. 6, 1880, p. 12. (2) Meyer's Geschichte der Chemie, p. 440. (3) Nature, 49-531, Apr. 5, 1894. Prof. Ira Remsen, Ded. of Kent Chem. Lab.

It was to that of the latter that Liebig gained admission in 1821, when he found it impossible to gain any practical instruction in Germany, for in all its schools there was not a single special chair of chemistry. Many Germans were being attracted to Sweden where Berzelius was beginning his great career. In 1824 Liebig was appointed to the professorship of chemistry at the University of Giessen. He accepted the position and, convinced that the only proper method of teaching chemistry was with a laboratory for the students, he succeeded in having one built. So the first laboratory for instruction was established and became one of the great forces of the world. From it rapidly developed the most flourishing and powerful school of chemistry that has ever existed.(1) "It was here," says Hoffman, "that experimental instruction such as now prevails in our laboratories received its earliest form and fashion and if at the present moment we are proud of the magnificent temples raised to chemical science, let it not be forgotten that they all owe their origin to the prototype set up by Liebig."

Laboratories rapidly multiplied and were supplied with trained and enthusiastic teachers from Liebig's pupils.

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(1) (1) Nature, 49-531.

This was not confined to Germany. When the first "College of Chemistry" in England was founded in 1846, Hoffman was appointed head-professor (1) and even those who had misgivings on account of his nationality were obliged to acknowledge very soon that it was very fortunate that this great German chemist had accepted the position for he brought laboratory work into English schools,(2) aroused enthusiastic interest in the students and gained great renown for the college and all England. From the universities and technical schools, the study of chemistry, first, without laboratory practice and later with it, has spread until it is now included in the curriculum of nearly all the higher institutions of learning.

In America, chemistry was recognized in the colonial medical schools, at first in connection with materia medica, as in the Medical School of Pennsylvania 1768, Medical School of Harvard College 1782, Dartmouth School 1798.(3)

The first academic college (4) to institute a separate chair for chemistry was Princeton in 1795, and Maclean was appointed to fill it. The example was quickly followed by Columbia College in 1800 and Yale in 1801. Mr. Benjamin

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(1) Report of R. Com. on Sci. Instruction, Vol. I.

(2) Nature, 38-470. (3) Boone's His. of Ed. in U. S.

(4) B. of E., Cir. of Inf. No. 6, 1880, p. 12.

Silliman was the first to hold the chair at Yale and shortly after his appointment saw the first experiment he had ever seen performed while visiting Maclean and his laboratory.

The courses offered in these institutions (1) were lecture courses. Text-books were very few, and in speaking of Yale, Silliman says "there was hardly a retort among the apparatus." (2)

Among the early instructors and graduates of the University of Pennsylvania, (3) there were many chemists of standing, which seems to indicate that its course must have been somewhat better than those then offered at other institutions. J. Woodhouse, who was the author of a number of chemical works of great value, occupied the chair of chemistry (1795-1807), at that institution which Priestly had refused. From 1814 to 1828 it was filled by R. K. Patterson, a pupil of Davy, England's greatest chemist. In 1829, James Curtis Booth graduated, soon afterward going to Europe where he studied under Wöhler (a pupil of Berzelius) in his private laboratory at Cassel and later under Magnus (another pupil of Berzelius) in Berlin and Vienna. Returning to Amer-

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(1) Boone's His. of Ed. in U. S.

(2) B. of E., Cir. of Inf. No. 2, 1893.

(3) B. of E., Cir. of Inf. No. 2, 1892.

ica he established in Philadelphia in 1836 the first laboratory for instruction in the United States. This was twleve years after Liebig had started the first one in Germany and ten years before England's first College of Chemistry was started.

In 1838, Dr. Charles T. Jackson of Boston opened his private laboratory for instruction to students and soon others did likewise. (1) Up to this time there had been no provision made for advanced teaching in America. In 1842, Silliman at Yale fitted up a laboratory at his own expense (2) and with $300 from a friend opened a private school and this was the germ of the Sheffield Scientific School which received its first endowment seventeen years later. In the same year, 1842, the Lawrence Scientific School at Cambridge began as a special school of chemistry.

"About this time a new period in American science began. Laboratory instruction in chemistry at least acquired a foothold in our system of education and our oldest universities gave it a friendly though sceptical welcome. (3) Year by year it grew in favor. It found its way beyond the scien-

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(1) B. of E., Cir. of Inf. No 6, 1880, p. 18.

(2) B. of E., Cir. of Inf. No. 2, 1893.

(3) F. W. Clarke, No. 6, 1880, p. 13. - B. of E., Cir. of Inf.

tific schools into the very colleges themselves, and the good results are visible to-day before the world."

The greatest impulse to scientific instruction (1) in America was given by the Congressional Act of 1862 providing agricultural and mechanical instruction. (2) Whether the land grant went to strengthen existing institutions as, in Connecticut, to Sheffield Scientific School, or to found new ones as in Illinois (3) by which our State University began, it has been the modern scientific departments which have reaped the greatest benefits. In the new institutions chemistry and laboratory work were included from the first, and until very recently our University of Illinois was able to boast of the largest and best appointed chemical laboratory in the west.

The High Schools of the United States are a growth of half a century. They have taken the place in a great degree of academies and other private secondary schools. "The youth of the state will henceforth receive their preparatory instruction for entering college in the Public High Schools instead of at the academy or seminary." (4) These words writ-

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(1) Boone's His. of Ed. in U. S. (2) B. of E., Cir. of Inf. No. 6, 1880, p. 14. (3) B. of E., Cir. of Inf. No. 6, 1886, p. 14. (4) Illinois Sch. report, 1857-8.

ten nearly forty years ago have been fulfilled. But the High Schools do more than this. They give secondary instruction to the masses. The elements of mathematics, literature and the languages are not the only branches taught, but in the last twenty-five years the elements of many of the sciences have found their way into High School courses.

This is especially true concerning physics, physiology, chemistry and botany. As in the colleges, these sciences first gained a foothold in High Schools without laboratory instruction, and slowly the change was wrought. Fifteen years ago, Mr. F. W. Clarke said "These (secondary schools) are organizing laboratories, teaching young scholars to see and experiment for themselves, preparing the way for higher work and rendering the latter more easily possible." (1) To-day there are very few High Schools in Illinois that pretend to teach chemistry without laboratory practice.

That chemistry or rather the elements of chemistry are well adapted to a place in secondary education need hardly be emphasized at this day. Fifteen years ago it was generally admitted that it was a desirable branch to teach in schools of this grade. In 1892 the Committee of Ten decided that at least two hundred hours should be given to the study

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(1) B. of E., Cir. of Inf. No. 6, 1880, p. 15.

of chemistry in High Schools and that it should be taught by a combination of laboratory work, text-book, and thorough didactic instruction and there should be no difference in treatment for those going to college or scientific school and those going to neither, that is, those whose education is completed upon graduation from high school. (1)

The High Schools in Illinois.

In Illinois there are somewhere near two hundred and seventy-four high schools, and it is the purpose of this paper to show the work in chemistry that has been done and is being done in them.

To gain the information on this subject, a circular letter was sent April 15, 1896, to every high school which had reported for the year 1894-5 to the State Superintendent of Public Instruction, requesting answers to a list of questions. About fifty replies were received. A second letter was sent May 1, 1896, containing the same list of questions, and this brought about the same number of answers so that the entire number of answers received was one hundred and fourteen.

Of the remaining one hundred and sixty-one some information concerning twenty-six was obtained by consulting the reports for 1895-6 sent to the committee on "Accredited Schools" of University of Illinois, and of sixty-two others

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(1) B. of E., Report of Com. on Sec. Sch. Studies, July, 1892, p. 117-118.

by consulting the reports for the years 1892-3-4-5. This leaves seventy-three high schools about which nothing could be learned.

The first high schools in this state were established shortly before the war; in 1854 one was established at Rockford, in 1857, Bloomington, in 1858 others at Chicago and Geneseo. A high school was already in existence in Peoria in 1858 and in Springfield in 1862.

So far as records show, chemistry was first taught in high schools of Illinois in Peoria 1859, in Quincy 1865, in Alton and in West Aurora 1867. Laboratory work was not introduced before 1870, the honor of the innovation appearing to rest with the Quincy High School. In 1877 it was introduced into the Sycamore High School, and in 1880 into those of Princeton and Pittsfield and in 1881 into that of Decatur.

Chemistry is now studied in 117 high schools of Illinois, the average time devoted to the subject being 118 hours. Laboratory work is practised in 75 of these schools, the average time being 85 hours. 37 schools require independent work of the pupil in the laboratory; in the others several pupils are permitted to work together. 25 include qualitative analysis, the time devoted to it varying from 10 to 40 hours. The number of pupils reported by the high schools to be studying chemistry this year (1895-6) is 1612. The total number must be, therefore, near 2000. This makes about a quarter of a million hours per year devoted to the study of chemistry in the public high schools of Illinois.

All the data that was obtainable has been collected and tabulated on the following pages.

The data in black was obtained from the answers to the circular letters; that in red from the Reports of High Schools for 1895-6; and that in blue from the reports for 1892-3-4-5.

In the tenth column, G means General Experimental work, Q means Qualitative work. In the eleventh column, S means several, and T means all pupils together. In column 12, when more than one text is mentioned, the other or others have been used previously, the text now used being the last mentioned. In the last column, the first set of figures refers to the value of the apparatus and the last to the value of the chemicals.

	County	Date of establishment of H. S.	Date of introduction of Chemistry	Date of introduction of laboratory work	Time devoted to chemistry at first	Time devoted to chemistry at present	Time devoted to lab work at first	Time devoted to lab work at present	Nature of lab. work	Number of pupils working together	Text books	No. of pupils in first class	No. in present class	Equipment
Abingdon	Knox		—	—	—	—								
Anna	Union		—	—	—	—								
Aledo	Mercer	1877	—	—										
Alexis	Warren	1887	—	—										
Alton	Madison				—	—	—							
Altona	Knox													
Amboy	Lee													
Arcola	Douglas		—	—										
Arenzville	Cass	1891	—	—										
Ashland	Cass													
Ashton	Lee													

	County.	Date H. S.	Date chem.	Date Lab. work	Hrs. at 1st	Hrs. now	Hrs. lab. work	Hrs. lab. work now	Lab. work	No. working together	Texts	1st class	Present class	Equipment
Astoria	Fulton		—	—										
Athens	Menard													
Atlanta	Logan	1871	1890	1895		140	105	105	G	1	Remsen		11	$500
Atwood	Piatt													
Augusta	Hancock					5×20 100					Remsen			$25.
Aurora E.	Kane	1879	1880	1890	20×4 80	46×7½ 300	20×1 20	40×5½ 220	$\frac{4}{5}$ G $\frac{1}{5}$ Q	1	Remsen with manual	6	24	Amply sufficient $200. $50
Aurora W.	Kane	1867	1867	1888	16×5 80	24×5 120	16×2 32	16×5 80	G	1	Youman Steele Remsen	5	14	$1,000
Austin	Cook					19×4 76		19×5 95			Shepard			$300.
Avon	Fulton	1886	—	—										
Auburn	Sangamon		—	—										
Barry	Pike	1880	1882			100			G	1	E. & S. Williams		6	Sufficient.
Batavia E.	Kane	1876	1895	1896	90	90		40	G	S	Steele- Remsen.	9	25	$25.
Batavia W.	Kane		—	—										$30.
Beardstown	Cass		—	—										
Belleville	St Clair					21×3 63					Remsen.			

Towns.	County.	Date H. S.	Date. Chem.	Date Lab. work	Hrs.	no. of Hrs.	Hrs. Lab. work	Hrs Lab work	Lab. work	No. working together	Texts	1st. class	Present class	Equipment
Belvidere N.	Boone		1891	1896	60	150	80	80	G	S	Williams		12	Very elementary $43.
Belvidere S.	Boone	1870		1894		100					Steeles Remsen or Shepard			Lab. in course of construction
Bement	Piatt	1880	1890	1894	17×3 51	100		80	G	2	Remsen		11	$45.
Blandinsville	McDonough													
Bloomington	McLean	1857	1869	1891		36×5 180	9×5 45	18×5 90	$\frac{1}{3}$ G $\frac{2}{3}$ Q	1	Steele Avery Shepard with manual		19	Complete for 19 pupils. $160.
Blue Island	Cook		—	—										
Bunker Hill	Macoupin		—	—										
Bushnell	McDonough		—	—										
Byron	Ogle													
Cairo	Alexander		—	—										
Cambridge.	Henry					36×5 180					Shepard's.			
Camp Point	Adams					15 × $2\frac{1}{2}$ $37\frac{1}{2}$					not yet selected			
Canton	Fulton		—	—										
Carlyle	Clinton		1885		no class this year. 5 mo. including lab. work									
Carmi	White					17×5 85					Clarke's.			

Town	County	Date H.S.	Date Chem	Date Lab work	No. Hrs	No. of hrs.	Hrs. Lab work	Hrs. Lab work	Lab. work	no. working together	Texts	1st Class	Present Class	Equipment.
Carrollton	Greene	1872		1886		20 150		80	G	1 or 2	Shepard's.		18	All that is needed $250.
Carthage.	Hancock			soon	Chem. will be taught as soon as provision made for a lab.									
Central.	Marion													
Centralia	Marion			1895	15 60	18 75	16	15 54	G	4	State Shepard Benton's Guide		16	Good & new. $150.
Cerro-Gordo	Piatt	1884	—	—										
Champaign	Champaign	1878	1894	1894	16x10 160	16x10 160	16x5 80	80	G Q	1	Williams	4.	43	$500.
Charlestown	Coles		—	—	—									
Chatsworth.	Livingstone													
Chenoa	McLean		—	—	—									
Chicago. N. Div.	Cook					160			G Q		Shepard			
" S. Div.	"	1875	1875	1895	40x4 160	160	40x2 80	80	G	S	Shepard & Lab. man.		113	Fair.
" Calument	"	1889	1890	1890	20x5 100	160		80	G Q	1	"	2	19	$45.
" Englewood	"	1870		1885	40x4 160	160		80	G		Shepard		80	
" English H. & Man. Tr.	"	1890	1891	1891	40x3 120	120	40x2 80	80	G Little a	S	"	15	40	$1500. $500.
" Hyde Park	"	1869		1884		40x4 160		80	G		Shepard		120	Good. $2500. 200.

Town	County	Date H. S.	Date Chem.	Date Lab. work	No. hrs. at first	No. hrs. now	No. hrs. lab. work	No hrs. lab. work	? Lab. work	No. working together	Texts	1st Class	Present Class	Equipment
Chicago - Lake	Cook	1884	1884	1884	40×5 200	160	100	80	G ½a	1	Shepard		40	$260.
" Lake View	"	1873	1873	1884	40 200	200	80	80	G	1	E.&S. 10 yrs. Shepard	5	60	good enough $350. 150.
" Jefferson	"	1883	1883	1883	40 200	160	160	120	⅓G ⅔a	1	Shepard A. & N. man.	3	35	good $2000.
Chillicothe	Peoria		1895	1895	36×2½ 90	90	90	90	G	T	Williams + man.	9	2	$180.
Chrisman	Edgar	1889	1895	1895	34×2 68	68	68	68	G	S	Benton Lab Guide	13	15	$25
Clayton	Adams													
Clinton	De Witt													
Clyde	Cook													
Cobden	Union		—	—										
Colchester	McDonough		—	—										
Collinsville	Madison					16×5 80					Steele			
Crystal Lake	McHenry													
Cuba	Fulton													
Danville	Vermilion		18(?)	1890	40×5 200	200		120	G ¼a		Shepard		20	15 desks - sufficient
Davis	Stephenson		—	—										

Town	County	Date H.S.	Date Chem.	Date Lab. work	No. hrs at first	No. hrs now	No hrs lab. work	No hrs lab.	Lab work	No. working together	Texts	1st class	Present class	Equipment.
Decatur	Macon	1862	before 1869	1881	22x5 110	22 176	3 15	10 50	$\frac{1}{3}$ G $\frac{2}{3}$ Q	1	Youmans Shepard		56	ordinary $1000.
De Kalb	Macon		—	—										
Delavan	Tazewell	1863				18x5 90			G	T	Avery		16	$150
Dixon	Lee													
Dixon N.	Lee	1886	1880	1894		20 50		about 12	G	S	Williams Shepard	5	16	$50. 25.
Downers Grove	Du Page	1879		Chem. dropped for want of lab.										
Dundee	Kane			1891		28x5. 146	14x5 70	70	G	1	Remsen			$100 25.
Du Quoin	Perry					24x5 120		102						$75
Dwight	Livingston					23x4 92					Avery			
East St. Louis	St. Clair	1873	1875	1893	20x2½ 50	30x2½ 75	12x1½ 20	20	G	1	Youmans Williams	8	12	Good $500.
Edinburg	Christian													
Effingham	Effingham	1887	1896			25x5 125					Williams Shepard.			
Elgin	Kane	1874	1884	1888	12x3 36	20x10 200		80	G	1	Remsen & man.		15	$175 25.
Ellsworth	McLean													
Elmwood	Peoria			School burned in fall 1895 no records — no class 1895-6.										

Town	County	Date H.S.	Date Chem.	Date Lab. work	No. hrs at 1st.	no. hrs now	no. hrs lab.	no. hrs lab.	Lab. work	no. working together	Texts	1st Class	Present Class	Equipment.
Edwardsville	Madison		—	—										
El Paso E.	Woodford		—	—										
El Paso W.	Woodford					38x5 190		38x3 114			Shepard + man.			$15
Eureka	Woodford		—	—										
Evanston	Cooke	1883	1883	1883	39x5 195	195	39x1 39	39x3 117	G	T	E&S. Williams	10	12	$500. $60.
Fairbury	Livingstone													
Farmington	Fulton													
Farmer's City	DeWitt					13x5 65					Williams			
Flora	Clay		—	—										
Forrest	Livingston					26x5 130					Steele			
Forreston	Ogle		—	—										
Freeport	Stephenson					20x5 100					Williams			
Fulton	Whiteside					21x5 105					Steele			
Fairfield	Wayne					18					Williams			
Galena	Jo Daviess		1895	1895	$18x7\frac{1}{2}$ 110	110			G	1	Williams + man.	10		$200.

Town	County	Date H.S.	Date Chem.	Date Lab. work	No. hrs. at 1st	No. hrs. now.	No. hrs. lab.	No. hrs. lab.	Lab.-work	No. working together	Texts	1st class	Present class.	Equipment.
Galesburg	Knox		1871			12×5 60					Steele			
Galva	Henry	before 1869	1869	1891	30 wks.	18 wks. 90		12 60	G_a	1	1871 - Steele 1885 " Pop. 1893. Williams		14	All necessary $150. $100.
Gardner	Grundy		—	—	—									
Geneseo	Henry	1858	—	—	20×2½ 50	50		50	G	2	Williams and " Man.		7	$100. 46.
Geneva	Kane					39×5 195					Shepard			
Genoa	DeKalb													
Gibson City	Ford					20×5 100		20×2 40			Remsen			$50.
Gilman	Iroquois					20×5 100		20×2			Williams			
Golconda	Pope.		—	—	—	—								
Grayville	White		—	—	—	—								
Greenview	Menard		—	—										
Greenville	Bond										not decided 1895			
Griggsville	Pike	1868				32×5 160		32×2½ 80	G_a	1	E. & Storer old & Revised.		15	Limited
Hamilton	Hancock													
Harvard	McHenry		—	—	—	—								

Town	County	Date H.S.	Date Chem.	Date Lab.	No. hrs. at lect.	No hrs. now.	No hrs. lab.	No. hrs. lab.	Lab. work	No. working together	Texts.	1st class	Present class	Equipment.
Harvey	Cook	1892	1895	1895	40 200	40 200	20 100	20 100	G	1	Williams		16	All necessary $200 $50.
Havanna	Mason													
Henry	Marshall	1873	1895	1896	13x3 39	20x3 60		20x2½ 50	G	S	Shepard's	22	15	
Highland Park	Lake	1888	1891	1891		16 40		16 60	G	S	Williams	1	7	Just enough for experiments in text-book.
Hillsboro	Montgomery	1881	1891	1894	12 60	24 180	24 80	24 80	G Q	2	Shepard	12	14	Ordinary $100 $15 a yr. $40
Hinsdale	DuPage		—	—	—	—								
Homer	Champaign		—	—	—	—								
Hoopeston	Vermilion	1895	1895		32 wks 5 hrs.	110 hrs.		no class yet.						
Ipava	Fulton													
Jacksonville	Morgan		1871	1889	14 70	28 180		26 180	G	2 or 3	Remsen	2	13	$250. $100.
Jerseyville	Jersey					34x5 170	with Exp.				Steele			
Joliet	Will	1875	1880	1882	16x5 80	38x5 190	16x1 16	38x2 76	G_a	1	Steele Shepard Williams		30	All necessary $150.
Kankakee	Kankakee			1892		12 wks.			G	1 or 6	Shepard			Apparatus homemade Variety of chemicals.
Kansas	Edgar		—	—	—	—								
Keithsburg	Mercer		—	—	—	—								

Town	County	Date H.S.	Date Chem	Date Lab.	No. hrs. 1st.	No hrs now	No hrs Lab.	No. hrs. Lab.	Lab. work	No. working together	Texts	1st Class	Present Class	Equipment.
Kewanee	Henry			1892(?)		36×7 252		36×5 180	$\frac{2}{3}$G $\frac{1}{3}$Q	2	Williams Hill's Qual		28	Full supply.
Kinmundy	Marion		—	—	—	—								
Kirkwood	Warren		—	—	—	—								
Knoxville	Knox													
Lacon	Marshall					19×5 95		19×3 57			Williams + " Man.			$75.
Lanark	Carroll													
La Salle	La Salle		—	—	—	—								
Lena	Stephenson		—	—	—	—								
Le Roy	McLean		—			27 100	Exp. in recitation		G	T	Avery		12	Sufficient $10
Lewistown	Fulton	1866	1889	1891	18×7 126	126	18×3 54	54	G	S 4=limit	Williams	3	17	good $100. $100.
Lexington	McLean				26×5 130	no class 1895-6					Williams			$15
Lincoln	Logan	1866				18×5 90	Gen. Exp. before class.				Steele Williams			$50. $25.
Litchfield	Montgomery					19×5 45		45			Shepard			$75.
Lockport.	Will		—	—	—	—								
Loda.	Iroquois		—	—	—	—								

Town	County	Date H. S.	Date Chem.	Date Lab.	No. hrs 1st.	No. hrs now	No. hrs lab.	No. hrs. lab	Lab work	No working together	Texts.	1st class	Present class	Equipment.
Mackinaw	Tazewell					12x2½ 30					Williams & " Man.			$15
Manteno	Kankakee		—	—	—	—								
Marengo	McHenry				16 80	none	most of 80	none	G	T	Steele not much used			Simple & cheap limited supply of chemicals.
Maroa	Macon		—	—	—	—								
Marseilles	La Salle		—	—	—	—								
Marshall	Clark													
Martinsville	Clark													
Mascoutah	St Clair													
Mason City	Mason	1876-9				16 100		16x2 32	G		Steele William man.			perhaps $200
Mattoon	Coles					16x5 96					Shepard			
Maywood	Cook			1893	20 66	24x5 80	33	40	G	1	Remsen		10	Sufficient.
Mazon	Grundy		—	—	—	—								
Mendon	Adams													
Mendota, E.	La Salle													
Mendota, W.	La Salle		—	—	—	—								

Town	County	Date H.S.	Date Chem.	Date Lab.	No. hrs 1st.	No. hrs now	No. hrs lab	No. hrs lab.	Lab. work	No. working together	Texts-	1st class	Present class	Equipment.
Macomb	McDonough					36×5 180		120	G	1			8	Sufficient.
Meredosia	Morgan					accident put chem. in "innocuous disuetude."								
Metropolis City	Massac													
Milford	Iroquois		—	—	—	—								
Milledgeville	Carroll		—	—	—	—	—							
Minonk	Woodford													
Molene	Rock Island					20×3 60		20×5 100			Shepard & man.			
Momence Union	Kankakee		—	—	—	—								
Monticello	Piatt	1878	188		20	12 84		20 84	G	T	Williams		14	not very good. $50 per yr.
Monmouth	Warren		—	—	—	—								
Morris	Grundy													
Morrison	Whiteside	1871	1884			40 110		50	G	S	Steele Williams			Sufficient.
Mound City	Pulaski		—	—	—	—								
Mt. Carmel	Washington		—	—	—	—								
Mt. Carroll	Carroll					28×5 140					Steele			

Town	County	Date H. S.	Date Chem.	Date Lab.	No. hrs lat.	No. hrs nom.	No. hrs. lab	No. hrs lab.	Lab. work	no. working together	Texts	1st Class	Present Class	Equipment.
Mt. Pulaski	Logan													
Mt. Sterling	Brown					24x5 120					Steele's			
Mt. Vernon	Jefferson		—	—	—	—								
Naperville	Du Page		—	—	—	—								
Nashville	Washington		—	—	—	—								
Nauvoo	Hancock		—	—	—	—								
Neoga	Cumberland		—	—	—	—								
Newman	Douglas		—	—	—	—								
Newton	Jasper					24x2½ 60					Shepard			
Normal	McLean		—	—	—	—								
Oak Land	Coles		—	—	—	—								
Oak Park	Cook		1893	1893	35 190	190		dem. & lec.	G	1	Remsen Teacher's notes		16	Suitable.
Odell	Livingstone		—	—	—	—								
Olney	Richland	1866	1880	1883	18x5 80	46x5 200		18	100		Steele 1898 Shepard		17	$200 $100
Onarga.	Iroquois		—	—	—	—								

Town	County	Date H.S.	Date Chem.	Date Lab.	No. hrs. 1st.	no. hrs. now.	No. hrs. lab.	No. hrs. lab.	Lab. work	No. working together	Texts	1st. class	Present class	Equipment.
Oneida	Knox	188(?)	—	—	—	—								
Oregon	Ogle					25x5 125					Shepard			$50
Oswego	Kendall													
Ottawa	La Salle	1879	1879		36 —	36x5 180		36x3 108	1/3 G 2/3 Q	1	Shepard since '85		25	all necessary $200.
Palatine	Cook													
Pana	Christian		—	—	—	—								
Paris	Edgar					18x5 90		18x2½ 45			Williams			$100
Paw Paw	Lee		—	—	—	—								
Paxton	Ford		—	—	—	—								
Payson	Adams		—	—	—	—								
Pekin	Tazewell	1867	1872	1892	36x5 2 hrs. per day		36x6 180		G	T	Steele Armstrong & Norton		18	$400
Peoria	Peoria					40x5 200			G Q					
Perry	Pike		—	—	—	—								
Peru	La Salle					20x5 100					Steele			$20.
Petersburg	Menard	1886	1889		18x3 54	54	Teacher performs 100 experiments				Cooley	6	14	$5 $5

Town	County	Date H.S	Date Chem.	Date Lab.	No. hrs. 1st.	No. hrs now	No. hrs Lab.	No. hrs Lab.	Lab. work	No. working together	Texts	1st Class	Present class.	Equipment.
Piper City	Ford													
Pittsfield	Pike			1880	17x4 68	no. lab. this year.				T	Shepard	?		fair new building 6
Plano	Kendall													
Polo	Ogle	1866	1892	1892	26x2 52	52	26x3 78	78	G Q	1	Williams.		14	Pretty good 8 tables $150.
Pontiac	Livingstone					26x5 130		26x3 78			Shepard + Manual			$400.
Prairie City	McDonough		—	—	—	—								
Princeton [Township School]	Bureau	1867	1868	1880	26x5 130	28x5 140		140	½ G ½ {Q Quan	1	Shepard + manual.		27	$2000. $1000.
Prophetstown	Whiteside													
Quincy	Adams	1865	1865	1870		24x5 140			G	S	Burritt Steele Remsen		36	$50. $25.
Rantoul	Champaign													
Ridge Farm	Vermillion		—	—	—	—								
River Forest	Cook													
Rochelle	Ogle	1864	Taught long ago but dropped owing to lack of apparatus.											
Rock Falls	Whiteside													
Rockford	Winnebago	1854			5x20 100	100	20x4 80	80	½ G Q	2	Shepard		40	$300 $100

Town	County	Date H.S.	Date Chem.	Date Lab.	No hrs 1st.	No hrs. now	No hrs Lab.	No hrs Lab.	Lab. work	No. working together	Texts	1st Class	Present Class	Equipment
Rock Island	Rock Island	1872				36×5 180		36×3 108	½ G ½ Q	1	Shepard		60	well supplied. room for 32 pupils at a time.
Roodhouse	Greene		—	—	—	—								
Roseville	Warren		1895	1895		25×3 75		75	G		Remsen		9	$25
Rossville	Vermillion		—	—	—	—								
Rushville Union	Schuyler	1872	—	—	—	—								
Salem	Marion		—	—	—	—								
Sandoval	Marion		—	—	—	—								
Savanna	Carroll		1894		26×2½ 69	69			G		not decided Steele's 1894	24	14	$25
Shabbona	De Kalb		—	—	—	—								
Shannon	Carroll		—	—	—	—								
Shelbyville	Shelby				one month of chemistry.									
Sheldon	Iroquois	1884	1896	1896	13 65	26 130	65	130	G	1 or 2	1884 Meads 1890 Norton	5	14	$150. 150.
Sorento	Bond		—	—	—	—								
South Chicago	Cook													
Sparta	Randolph	1865	1893	1893	36	32	irregular		G	1 2 or 3	Roscoe Eggs. Rolfe 10" Steele Pop.			$200 buy as needed

Town	County	Date H.S.	Date Chem.	Date Lab.	No. hrs. 1st	No. hrs. now.	No. hrs lab.	No. hrs. lab.	Lab. work	no. working together	Texts	1st. class	Present class	Equipment.
Springfield	Sangamon					40x5 200		40x3 120	$\frac{2}{3}$G $\frac{1}{3}$Q	2 desks limited			45	all that is necessary.
Sterling	Whiteside	1875	1880			19x6 114		19x4 76	G a	1	Williams & manual.		23	Equip. for Williams.
Streator	La Salle													
Sullivan	Moultrie			1895		24x5 100		18x5 90	G	1	Williams		5	$60. 25.
Sumner	Lawrence													
Sycamore	De Kalb.	1875	1877	1877	12x5 60	60	60	60	G	T	Steele's 14 yr. Williams 14 yr. Steele's New	6	16	$150 50.
Table Grove	Fulton													
Tallula	Menard													
Taylorville Township H.S.	Christian	1891	1891	1894	20 100	26 130	52	65	G a	1	Shepard	5	11	$200 $75
Thompson	Carroll		—	—	—	—								
Tolono	Champaign		—	—	—	—								
Toulon	Stark													
Tuscola	Douglas					16x5 80					Shepard			
Urbana	Champaign		—	—	—	—	—	—						
Vandalia	Fayette		—	—	—	—								

Town	County	Date H.S.	Date Chem.	Date Lab.	No. hrs 1st.	No. hrs. now	No. hrs lab.	No hrs. lab.	Lab. work	No. working together	Texts	1st. class	Present class	Equipment.
Vermont	Fulton													
Vienna	Johnson		—	—										
Virden	Macoupin		—	—										
Virginia	Cass		—	—										
Warren	Jo Daviess	1875	1895	1895	26 100	100			G	1	Williams & manual			$50. 50.
Warsaw	Hancock					30x5 150					Williams			
Washburn	Woodford		—	—	—	—								
Washington	Tazewell	1880		1895		20x5 100		100	G	2	Williams & manual		17	new $75. $65.
Waterloo	Monroe		—	—	—	—								
Watseka	Iroquois					20x5 100					Remsen			
Waukegan	Lake	1870(?)	1891	1891	20	28	30	42	G	1	Williams	15	16	Sufficient for class of 20 - $150.
Waverly	Morgan		—	—										
Wenona	Marshall	1885	1895	1895	15 75	75	75	75	G		Williams	8	8	all necessary $60. 25.
Westfield	Clark		—	—										
Wheaton	Henry					38x5 190		38x3 114	½ G ½ Q	1	Remsen		12	12 desks. all necessary $600.

Town	County	Date H.S.	Date Chem.	Date Lab.	No hrs at 1st	No. hrs.	No. hrs lab.	No hrs lab.	Lab work	No working together	Texts	1st class	Present class	Equipment.
White Hall	Greene	1875	—	—	—	—								
Wilmington	Will	1883	1892	1892	14×5 70	70	70	70	G	T	Williams	9	10	Do 100 exp.
Winchester	Scott		—	—	—	—								
Winnebago	Winnebago													
Winnetka	Cook													
Woodstock	McHenry					12×5 60	Everything illustrated			1	Steele Williams		14	Home made complete stock of chemicals
Wyoming	Stark	1889	1893			24×2½ 60	Everything illustrated	60	G	T	Williams	14	14	all necessary
Yorkville	Kendall					13 130		65	G	Pupils help teacher	Avery		13	$12 $10

Summary.

Total no. of H. S.	Av. time to chem.	Av. time to lab. work	Total no. in present classes.
274.	118 hrs.	85 hrs.	1612.

Summary showing the number of High schools with and also those without chemistry and laboratory work and the origin of that information.

Origin of Information	No. of H.S. of which information was obtained	No. of H.S. with Chemistry	No. of H.S. with lab. work in chem.	No. of H.S. without Chemistry.
From answers to circular letters Apr. 15 + May 1, 1896	113	80	65	33
From reports of H.S. to U. of I. for 1895-6	26	15	7	9
" " " " " " " 1892-3-4-5	62	22	3	40
Total	201	117	75	82

There are 274 high schools on lists and probably the majority of the 73, about which nothing could be learned, have no chemistry in their course. They are mostly in small towns and it is doubtful if many of them deserve to be called high schools.

Table showing the number of high schools with chemistry and with laboratory work for years 1870, 1880, 1890 and 1895, taken from 113 replies to circular letter.

Year	1870	1880	1890	1895
Number of High Schools	18	45	62	113
" " " " with chem.	9	22	34	80
" " and laboratory practice	1	4	23	65

The figures for 1880 and 1890 are probably too low as many of these 113 high schools had no records.

From these tables, incomplete as they are, we see that Illinois has had high schools hardly forty years. That chemistry gained foothold in her high schools hardly thirteen years ago and laboratory work about fifteen years ago, and the spread of both has been wonderful.

The time devoted to chemistry, in most instances, has increased and the number of pupils has increased with the growth of the schools and increase in population of the towns.

Summary showing the text-books used and no. of schools using each.

Text-books.	No. of H. S. according to letters of Apr. 15 - May 9.	No. of H. S. according to reports 1895-6	No. of H. S. according to reports of 1892-3-4-5.	Total no. of H. S.
Williams	26	3	6	35
Shepard's	22	8	5	35
Remsen's	14	3	2	19
Steele's	2	2	8	12
Avery's	2		1	3
Clarke's			1	1
Eliot and Storer's	1			1

5 schools using Shepard also use manual in laboratory.
4 " " Williams " " " " "
1 " " Remsen " " " " "

Of about twenty schools reporting on texts previously used more than fifteen had used Steele's "Fourteen Weeks in Chemistry." In fact, fifteen years ago the favorite text-books in use were Steele's Fourteen Weeks in Chemistry, Youman's Classbook of Chemistry, Eliot and Storer's Manual of Inorganic Chemistry and Stockhardt's Experimental Chemistry. From a study of these texts a fair idea may be gained as to the character of the work that was then done. (Cir, of Inf., No. 6, 1880.)

These books are treatises with illustrative experiments on the properties of substances with more or less mention of chemical principles, laws and terms. In "Eliot and Storer's Manual" fewer principles than usual are mentioned, but the number of experiments is larger than usual or than seem desirable. Two hundred and twenty-eight experiments required a good deal more time than is usually devoted to the study of chemistry in any of our high schools to-day, and from the table it will be seen that the time is greater than it has been ever before. The treatment is common --- a few definitions, then air and its constituents and then water and the preparation of O and H --- then the other elements and compounds, their properties and reactions being treated quite fully, especially those of the carbon compounds.

The subject matter in Stockhardt's Experimental Chemistry is in four general divisions: Physical phenomena, Chemical laws, Study of properties of the elements, and Organic Chemistry. Each part except the second is amply illustrated by experiments. The chapters which deal with Physics and its laws are the best in the book, for no where else is there that close connection and relation between text and experiments which renders them mutually dependent. The text is very clear and logical.

The Chemical laws are next taken up with but four experiments. In forty pages there is presented to the student all the theories and laws of chemistry and its nomenclature.

Then each element is taken up separately and its properties and compounds studied by experiments and thus the observing faculties seem to be called more into play than those of reason, for the conclusions have been stated before.

The last division in the book deals with the principal groups of carbon compounds, their properties and general reactions.

For an ordinary beginner there are too many experiments, too much theory at first and not any later where one would be better prepared for it. The student finds he knows a large number of facts about a large number of elements and compounds, their properties and behavior but he does not seem to be called upon to apply this knowledge to induce any principles. This statement may be said to hold for all of the elementaty chemistries of a few years ago and some of to-day.

At present the text-books most used are Shepard's, Williams', and Remsen's.

In Illinois	35	High	Schools	use	Shepard's
	35	"	"	"	Williams'
	19	"	"	"	Remsen's.

Plan of books.

Shepard's

1. Historical sketch.
2. Definitions and rules
   Atoms, atomic weights and formulae.
3. Non-metallic elements
   Preparation and properties
   Compounds
   Tests
4. Molecular theory and
   Natural classification.
5. Metallic elements
   Occurrence
   Properties of compounds
6. Method of separation.

Williams'

1. Definitions
   nomenclature
2. Manipulations
3. Properties of elements and compounds
   with theory
   interspersed throughout
   in following order---
   a. Union by weight
   b. Valence
   c. Acids - bases - salts
   d. Laws of Definite and Multiple Proportion
   e. Vapor Density and molecular weight
   f. Atomic weights. (of gases)
   g. Diffusion and condensation
   h. New theory of chemistry
   i. Gas volume and weights

Plan of books. (con.)

Remsen's

1 Physical and chemical changes.

mixtures and compounds

compounds and elements

nomenclature

chemical action

2 Air causes changes.

(Indestructibility of matter)

3 Chemical energy.

4 Combining weights.

Laws of Definite and Multiple Proportion

Symbols, Reactions.

5 Law of Definite Volume.

6 Metals, acids, bases, salts.

7 Chemical work and conservation of energy.

8 Atomic Theory

9 Chemical analysis explained.

10 Families of elements

leading to comprehension of Periodic law.

In the preface of his book Mr. Shepard states that he has found that the same general plan is being pursued by the best teachers in all sections of the country. It is very simple, but it is a question whether it is best for elementary work.

A historical sketch introduces the student to the study of the past of chemistry. Although so largely composed of names, it nevertheless awakens his interest and he then begins on the next chapter of "definitions and rules" with more vigor and attention. Immediately after he starts to make the acquaintance of the elements, their compounds and the methods of their separation and determination. Exercises at the end of every subject make him familiar with the processes of calculation and chemical arithmetic.

The experiments are numerous but are almost entirely qualitative and moreover are such that the reasoning faculties in interpreting results are not called upon often enough. The results of the experiments are always told; hence, the performing of them simply serves as proofs of the truth of the text. A pupil is apt to become careless and inattentive when the results of all his experiments have been stated beforehand.

For elementary work unnecessary time is spent on uncommon oxides and acids, as Cl_2O, Cl_2O_3, Cl_2O_4, $HClO$, $HClO_4$, etc. Reactions are not always simple enough for beginners, as

$$AgNO_3 + 2Cl = NO_2Cl + AgCl + O.$$

The "queries" are not of the kind to increase the pupils' reasoning powers, for example

Page 40-	Page 41-
Hydrogen and oxygen form a chemical compound water, H_2O ---	Question --- What is the chemical composition of water and its formula?

The questions at the end of the chapter require a greater outlay of time than is desirable. The time given to chemistry is so short under any consideration, that it ought to be spent only on the more important principles and there is much that is more important and more necessary than the matter treated in the "questions."

In speaking of the decomposition of ammonia gas by electric current, and the two volumes of gas formed, the statement is made that besides the other significations "that the formula of a gas always represents two volumes of that gas." This is a most unusual statement.

Williams, in his preface, lays special emphasis upon the desirability of having the pupils become early acquainted with formulae and equations, the 'multum in parvo' of chemical knowledge, as he says. Classification of salts, bases and acids is insisted upon. "The mathematical and theoretical parts are interspersed where needed, thus avoiding the tedium of many chapters of theory." The author attaches value to experimental work, but advises teacher to perform most experiments before the class, before the pupils are required to perform them or to recite.

It would seem that the keen interest of pupils would not be kept alive by simple repetition of experiments. When a pupil knows what ought to happen, he either is satisfied and does not repeat it or does it carelessly.

The experiments are not numerous, more attention being paid to statement of uses of the various compounds and to the discussion of laws, theories and technical subjects, all, of necessity, being treated in a somewhat superficial manner.

The experiments are not unusual, (mostly test-tube experiments), nor do they seem to be chosen for any particular value they have except in illustrating the properties of elements and compounds.

At the end of every subject, all the most important matter in it has been collected in a few clear, concise sentences under the heading of "Resume." Everything, the discovery of which by the pupil would tend to keep alive his interest, is simply given him in a concise manner easily retained by the memory, while his reasoning powers are developed by such questions --- "When NO changes in air to NO_2, where does the O come from?"

Such directions as "examine bromine, iodine, potassium, sodium bromide" etc. are too vague. An average student would be at a loss just what to do.

The expression, "size of half atoms of H," etc. is used in explanation of atomic weight. According to the fundamental conception, an atom is an indivisible particle. How can an indivisible thing be halved? Since, according to our theory, "half-atoms" cannot exist, it is irrational to use this idea in explaining the relations of atomic weights and methods of their determination. The text also incorrectly states that "3 atoms of O are condensed into space of two atoms of ozone." (p. 84) Ozone is an allotropic form of oxygen, containing three atoms of oxygen in the molecule. Atoms of ozone do not exist.

Symbols and formulae are given undue prominence. They are totally unnecessary for a clear, intelligent knowledge of elementary science. Remsen said several years ago that he "sometimes thinks, and the intervals between the thoughts are getting shorter, that if the use of formulae were <u>given up entirely</u> in elementary instruction, better results would be obtained." A young pupil, in trying to remember the formula or reactions, overlooks far more important statements, perhaps the very conditions only under which the reaction may take place.

The explanation of Vapor Density is neither natural nor easily comprehended. The experiments do not bring out important laws but simply introduce the pupil to some of the properties of some of the elements and compounds. The text is like that of an ordinary book, more like an elementary chemical cyclopedia, notwithstanding the author's intention to make it an "inductive, simple, practical experimental text-book for the average high school."

In the preface to "The Elements of Chemistry" Mr. Remsen says the book is intended for younger pupils, therefore, "theories are subordinate, allowing attention to be directed to simpler chemical facts and methods by which these are learned." A course must "help pupils to think and reason as well as observe and see or it is not rational." This book is remarkable in the first hundred and fifty pages for its simplicity and clearness. The order of the subject matter so far exceeds that of most books that they ought hardly to be compared to it. A very young pupil would hardly find Remsen's text difficult or uninteresting. In the latter part the matter seems somewhat fragmentary, making the study of that part principally memory work. The experiments do not seem to be quite so well adapted or so valuable. It is said that this latter part was added at the request of teachers who wanted some of the principal elements and compounds treated as is customary. The extraction of K_2CO_3 from ashes is rather bunglesome as is the manufacture of soap from lard. Qualitative analysis is explained but the tests and determination of substances is rightly omitted. "The periodic law," although not stated, is placed in the pupil's hands in such a way that he is acquainted with it, though he does not know it by name. ~~(Nature, 31-369)~~

Altogether it seems that this book is better by far than many commonly used in high schools. When the book first came out, a press notice pointed out that there had been an attempt to cover too large a field and that the technical processes were not simple enough. Otherwise the order and arrangement was excellent, tending to widen general knowledge and to cultivate thinking. (Nature, 37-317)

In speaking of the present method of teaching elementary chemistry in general Mr. Patterson Muir says "However enthusiastically a pupil begins, he finds he is not progressing. When he has been told and shown the properties of H, O and H_2O, he is expected to take as much interest as ever in hearing a list of the properties of N and nitrogen oxides. Then he fills his books with as many facts regarding ammonia and nitric acid and so on. Chemistry is a branch of science and may be taught as such. It is possible to have a course so arranged that principles are discussed and amply illustrated by well chosen experiments instead of being a repitition of disconnected facts of a string of elements and compounds."

Two books have lately been published which seem based upon this idea. In both, discussions of principles with well chosen experiments illustrating these form main part of the books. These are "An Elementary Chemistry" by White and Freer's "Elements of Chemistry" and no doubt will come into more general use so soon as the idea that qualitative analysis may be omitted in elementary work comes into more favor.

Plans.

White.

1.General experiments to acquaint pupil with chemical

properties of elements.

2 Two kinds of changes.

3 Law of Boyle.

4 Weight and specific gravity of air

Law of Dalton.

5 Conservation of mass.

6 Law of definite proportion by weight.

7 Law of multiple proportion.

8 Dalton's atomic hypothesis.

9 Combining weights.

10 Molecules

11 Relative weight of atoms.

12 Law of definite proportion by volume.

13 Molecular theory of gases.

14 True atomic weights and methods

Spefic heats. Isomorphism.

15 Periodic law.

16 Nomenclature and symbols.

Plans (con.)

Freer.

1 Physical and chemical changes.

2 Law of conservation of mass.

3 Elements, compounds, nomenclature.

4 Solutions.

5 Law of definite proportion by weight and volume.

6 Changes of energy. Chemical energy.

7 Acids, bases, neutralization.

8 Law of multiple proportions, valence.

9 Boyle's law.

10 Charles' law.

11 Equivalent weights.

12 Atomic theory, molecules.

13 Relative weight of atoms.

14 Molecular theory of gases.

15 Determination of atomic weights.

16 Formulae and equations.

17 Determination of chemical formula for CH_4.

18 Valence.

19 Metathesis and causes of double decompositions. Solution.

20 Families of elements.

White takes a pupil into the laboratory first of all and after a little preliminary work with metric system of measurement, gives explicit and easy directions for making a wash bottle. Then he conducts a number of quantitative experiments showing the effect of air on heated metals, preparation of some of the more common gases, acids and salts. It is purely inductive. The pupil names everything and reasons all out alone, a few suggestive questions being all there is to aid him. After becoming tolerably well acquainted with chemical methods and facts, the study of the science is begun in historical order. This part of the book is most excellent. The experiments are numerous and explain the text and lead up without a break to the conclusions to be drawn. Symbols are not used at all, their use,with the Latin and English names of elements is explained in last chapter. Qualitative and quantitative analysis are illustrated by one or two simple experiments. The use and importance of these branches is thus properly shown.

Then, in favor of this book, let it be said that the general principles and laws of the science are naturally developed, that the questions are put in the right places, that the interest of the pupil is insured, that the pupil is early taught to handle apparatus, and to set it up accurately, and that he is not bothered with formulae, symbols and reactions before he understands their value.

There are so many "CAUTIONS" that a pupil may become so familiar with them as to disregard them and grow careless. The course embraced by the book is too extended and elaborate for an average high school.

The greatest amount of time given to chemistry in any high school in Illinois is 200 hours, which is the time the experiments alone in this book require, while in the great majority of high schools the time is a great deal less.

Freer starts out in a natural manner, interesting and truly encouraging, to discuss briefly changes in matter, conservation of mass and nomenclature. Then, by consideration of a very few of the most common elements and their simplest and most important compounds, the principles and laws are induced.

The author believes that physical chemistry should not be neglected in elementary courses but his introduction of bits of it seem a little forced and unnatural, as in the discussion of the laws of solutions in speaking of water and its solvent powers. Changes of energy and chemical energy are treated somewhat elaborately but not very clearly or simply.

The eighty-one experiments, mostly of a quantitative character, are gathered at the end of the book, but are supposed to be carried on in connection with the text. The apparatus needed may be a little too expensive for many high schools. Yet the experiments are well chosen and are well explained by the text. Formulae and symbols are introduced a little early, yet it can hardly be said that undue prominence is given to them.

" The study of natural science loses its value as a means of cultivating the faculties when the method employed fails to lead to the observation of and experimenting with the objects of nature.... Instruction in science becomes unprofitable when it is not based on the pupil's own observation and activity. Another element should receive equal consideration. Just as necessary as an acquaintance with the archetypal forms of nature by direct inspection, and of the observational facts by direct experiment, is the unifying, reasoning process, which sits enthroned above the myriads of facts and is as important a condition of observation as the activity of the senses and hands. Reason with its generalizing powers is the compass which alone prevents the student from becoming bewildered in the maze of details." (Supt. F. L. Soldan of St. Louis, in Ed. Rev., April, 1896, 351-2.)

It has been said by a number of eminent teachers that elementary chemistry, when properly taught, with laboratory practice should teach a pupil (Ed., 6-635) to use his senses, to become self-reliant, to be scientifically exact, should tend to (Nature, 49-532) form a scientific mind, one which deals with questions objectively and judges on merits and not to prejudge, should (Shepard's, --- To the teacher---) awaken and cultivate the spirit of investigation, encourage student to ask nature questions which in chemistry are answered with unusual conciseness and clearness, lead to concentration of thought and energy and (White, Preface) should require careful attention to details, accurate observation and lead to the high development of the reasoning powers. All of which will be as useful to the general student as to the one who expects to continue science studies.

Now has the study of chemistry in our high schools done all this for the pupil? Is it doing it? It has not done all this. It has taught him perhaps, to use his hands, to observe and to use his memory in remembering certain chemical facts. It seems that the reason it has not done more is on account of the greater importance which has been attached to its practical utility in every day life rather than to its importance as a mental discipline.

This can be seen from what Mr. Clarke said in favor of elementary chemistry being taught to girls. A knowledge of chemistry is valuable to women in determination (Cir. of Inf., No. 6, 1880) "in the laundry of the relative merits of different soaps, and the peculiar properties of hard and soft waters, what will whiten cloth without rotting the fiber, how can stains be removed from linen, which colors are fast, which are fleeting, etc."

With boys an elementary course was all that was desired if it enabled them to analyze and identify substances, and this is somewhat true to-day.

A high school course is hardly the place for the expounding of such knowledge. Some of it can best be gained by experience, some by reference to a receipe book and some only by advanced work at some technical school.

Qualitative analysis as practiced in high schools, is mostly by "rule of thumb," and this fascinating application (fascinating because the pupil feels he is doing something) of chemical knowledge becomes to the student the apparent end of all chemical science and is all that is worth knowing. It is a good deal the same with chemical formulae when too early introduced and made too prominent. A pupil feels when he can rattle off a few formulae, he knows chemistry and many are the otherwise intelligent persons who thrill themselves and think that they thrill a chemist's soul by proudly greeting him with "H_2O" or "H_2SO_4" the only remnants of their chemical training.

Surely, such results are not desirable whether one continues the study or not and the gain derived from such a study is not to be compared to that gained by a broader but deeper study of the facts of chemical science and inquiry into the principles and laws which are found to govern them. The latter method prepares one to deal with questions outside of the laboratory and without chemical apparatus and it surely forms a better foundation for further study in that or any direction.

A course in chemistry for high schools, then, should consist of such a course that the fundamental laws and principles should be given in simple and natural sequence illustrated by experiments of such a character and worded in such a way that the pupils reasoning powers as well as his powers of observation are cultivated by being required to work out in part, at least, some of these laws and principles and their relations.

The peculiar dicipline of chemistry comes through the proper use of the laboratory. (Ed., 6, 635) Too often laboratory practice is confined to mere observation of the properties of substances.

In the report of the Committee of Ten, a list of one hundred experiments in chemistry appropriate for high schools was recommended. A hundred experiments is too large a number for an elementary course. In the list suggested ~~to~~ too many elements and compounds are studied, too large a field is covered, too few principles are illustrated. There are a few quantitative experiments but they say truly that they are hard to find. The experiments selected from Cooke's Manual are the most valuable. Altogether their list of experiments is rather discouraging.

In most text-books the experiments are not arranged in a logically connected series. Too often they are simply an unconnected, miscellaneous mass of distinct and different phenomena in which it would be difficult to recognize any general relations, and which furnish the pupil with poor material for reasoning. The student ought to be required to think and reason logically from that which he has done himself. This seems to be the hardest thing for a pupil to do and it should be made as easy as possible by having each experiment lead on naturally and logically to the next. By a few experiments the pupil finds that there are distinctions to be made in changes, that substances which undergo chemical change are of two general classes. From the consideration of compounds and elements the law of "Conservation of Mass" naturally follows. That suggests reference to the law of the "Conservation of Energy." By work on combining weights and neutralization the laws of definite proportions by weight and volume are readily comprehended. On forming an acquaintance with multiple proportions, the pupil is ready for some explanation which will account for the truth enunciated by these laws and this he gets from the atomic theory.

To explain behavior of gases after confirming Boyle's and Charles' laws, the "molecular theory of gases" is evolved. Then the determination of atomic weights becomes alive with interest to the student and formulae may be introduced when he is fully able to comprehend their use. A study of the principle elements of two or three families ought to be sufficient to help the pupil to appreciate the periodic law.

Such a course in laboratory work may be outlined as follows:-

P l a n.

1. Physical and Chemical Changes.

   Compounds and Elements.

   Mixtures.

2. Conservation of Mass.

3. " " Energy.

4. Combining Weights and Neutralization.

5. Laws of Definite Proportion by Weight and by Volume.

6. Law of Multiple proportions.

7. Atomic Theory.

8. Boyle's Law. Charles' Law.

9. Molecular Theory of Gases.

10. Determination of Atomic Weights.

11. Formulae. Symbols.

12. Families. Periodic Law.

Chemical and Physical Changes.

Two Kinds of Changes.

1. Dissolve about 1 gram of table salt in 10 c.c. of water. Evaporate water and examine residue as to color, taste, solubility.

2. Place some iron filings in a test-tube and pour over a little dilute sulphuric acid with water and heat gently until all is in solution. Evaporate the liquid and examine the residue especially comparing it with the iron filings, as to color, form and solubility.

   Is there any difference in the changes which have taken place? What is the difference?

3. Hold a platinum wire in the flame of a Bunsen burner and closely observe all that occurs, both while it is in the flame and out of it, and its properties before and after heating.

4. Do the same with a piece of copper wire.

5. With forceps hold a piece of magnesium ribbon in the flame and observe effects.

   What are the different effects of the heating in three, four and five? In which cases so far has there been no change of substance? In which have there been changes of substance? Call the former physical changes and the latter chemical changes.

6. Dissolve a few grams of dry powdered sodium carbonate in about four times as many c.c. of water and evaporate to dryness. Compare residue with the sodium carbonate.

7. Have a few c.c. (15 or 20) of hydrochloric acid and stir into about 5 grams of carbonate of sodium and when clear evaporate to dryness and examine residue as to color, appearance, taste, solubility, action of hydrochloric acid and comparing it with carbonate of sodium.

What are the residues in 6 and in 7? How do you distinguish them?

Compounds and Elements.

8. Place a very little red oxide of mercury in a hard glass tube closed at one end and heat. When any action takes place insert a lighted match in the tube. What is the result? To what is it due? Continue heating until there is no more change. What is left? Which should you think would weigh more, what you had at first or the residue? Why? What would you call a substance composed of more than one kind of matter?

9. Weigh accurately a crucible and cover and then place in

it some (1 gram) iron filings and weigh again. Heat on triangle over a good burner, lifting the lid every little while and stirring with a platinum wire, being very careful not to lose any. When all action has ceased, allow it to become perfectly cold and weigh again. What has happened? What has caused the change?

10. Weigh out a little iron filings and dissolve in sulphuric acid and evaporate to dryness. Weigh the product. What has happened in this case? When an element cannot be separated into two or more different kinds of substances and if, when it reacts with others, the product always weighs more than the original substance, it is called an element.

Mixtures and Compounds.

11. Try the effect of the magnet on iron filings- on same quantity of rolled sulphur. How are they affected? Mix the filings and sulphur intimately. Try the effect of magnet on the mixture. Explain the result. Is it a physical or chemical change?

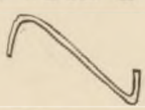
12. Mix equal quantities of iron filings and sulphur and place in a test-tube heating until the mass begins to glow. Observe. Try the effect of magnet on mass. Is

the effect the same as in 11? Explain. Can you separate the iron filings and sulphur? Is it a physical or chemical change?

When substances are mixed and only undergo a physical change mixtures are formed. If they undergo a chemical change compounds are formed.

13. Grind in a mortar a small piece of potassium iodide and same amount of corrosive sublimate. Note appearance of each. Any changes? Add a little water and stir. Effects? What kind of a change? Why? Is it a mixture or a compound?

Conservation of Mass.

14. Heat a little potassium chlorate in a tube and insert a lighted match. Do you recognize the phenomena? In a weighed tube place an accurately weighed quantity of potassium chlorate (2 grams) and fit with a one hole cork containing a doubly bent tube,  leading under an inverted cylinder filled with water in a vessel of water. Heat the tube containing the potassium chlorate. What takes place? Continue heating until there is no more action. Cool the tube containing residue of the potassium chlorate and weigh. Note carefully the volume

of gas in the cylinder after adjusting levels and read thermometer and barometer. From the corrected volume the weight of the gas may be calculated, 1 c.c. under standard conditions weighing .001429 grams, (at ordinary temperature and conditions of laboratory .00134 grams). Compare weight of potassium chlorate taken with the sum of the weights of the residue and the gas given off. Has there been gain or loss?

The gas given off is oxygen.

15. Usual lecture experiment of combustion of candle with caustic soda above on a counterpoised balance.

Conservation of Energy.

Try effect of acids on metals.

16. Prepare hydrogen in usual manner and when all air is out of apparatur put a platinum tip on the end of the delivery tube and light the hydrogen. Place a beaker over the flame. What gathers on the sides of the beaker? Taste. Introduce the lighted jet into a jar of oxygen. What takes place? What is formed? Of what has it been formed? What conclusion do you draw about the atmosphere? Hold a match in the flame; a platinum wire. What characterizes the flame? What attends the formation of the compound?

What should you think would attend the decomposition?

17. Decomposition of water by electric current. As a high enough temperature to decompose water is not practically possible, we have to resort to the electric current. If the amount of electrical energy necessary to decompose a given quantity of water is transformed into heat energy, it is found to be exactly equal to the amount of heat energy which was given out at its formation.

Combining Weights.

18. Repeat experiment 9, using about .5 grams of magnesium powder instead of iron filings. Calculate the quantity of magnesium which has united with 8 parts by weight of oxygen.

19. In a weighed crucible, weigh off about 1.5 grams of tin and heat gently adding concentrated nitric acid drop by drop so long as action takes place. Then heat to redness until weight is constant. Calculate the quantity of tin which has united to 8 parts of oxygen.

Neutralization and Definite Proportions.

20. Try effects of acids on litmus. Of alkalies. To 5, 10 and 15 c.c. of caustic soda solution of known strength add hydrochloric acid solution carefully to each successively until the neutral point is reached, the vol-

ume of acid required in each case being carefully recorded. Evaporate neutral solutions to dryness and weigh.

Add excess of acid to 5 c.c. and to 10 c.c. of caustic soda solution. Evaporate and weigh. Compare all products. What effect has excess of acid?

To 5, 10 and 15 c.c. of caustic potash add hydrochloric acid solution until neutral point is reached. Repeat, using nitric acid. Tabulate results. Are there any apparent relations between amounts of solution necessary to neutralize each other?

All experiments illustrating multiple proportions are hardly simple enough for elementary work.

Experiments illustrating Boyle's and Charles' laws, the molecular theory of gases and determination of atomic weights, are admirable in White's Elementary Chemistry,---pages 126 (Boyle's law), 143 (Charles' law), 185 (Regular expansion of gases, molecular theory of gases), 196 (Determination of atomic weights).

Experiments illustrating the similarity of the properties of the members of families are especially good in Remsen.

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